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CW and Q-Switched performance of a diode end-pumped Yb:YAG laser[1]

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ABSTRACT:

Using scaleable end-pumped technology developed at LLNL we have built and demonstrated a Yb:YAG laser capable of delivering over 100W of CW power and 10 mJ of Q-switched energy in a 40 ns pulse with $M^2 < 7$.

SUMMARY:

Many potential applications motivate the development of efficient, compact 1 μm laser systems with operational lifetimes capable of exceeding thousands of hours. Yb-doped laser hosts offer spectroscopic and laser properties that make them promising candidates for high power 1 μm laser systems. In particular, Yb:YAG has a long storage lifetime of 951 us and a very low quantum defect resulting in less heat generation during lasing than comparable Nd based systems.[1] In addition, the broad pump line at 940 nm makes this material highly suitable for diode pumping using InGaAs based diode-pumped lasers that are more robust than AlGaAs diode-pumped lasers which are used to excite Nd:YAG at approximately 808 nm. Because the 940 nm absorption feature in Yb:YAG is approximately 10 times broader than the 808 nm absorption feature in Nd:YAG, the Yb:YAG system is less sensitive to the diode wavelength specifications.

Figure 1 is a sketch of our end-pumped Yb:YAG laser. The pump source consisted of a 43 bar stack of 1 cm long InGaAs laser diode bars packaged on microchannel coolers. The diode pump light is first conditioned by a uniquely shaped microlens directly mounted on each diode package. The microlens allows the diode light to emerge with a far field 1/e divergence of ~10 mrad and 150 mrad in the fast and slow axis directions, respectively. The pump light is then focused or concentrated down with a fused silica lens duct to allow for end-pumping of the laser rod. The Yb:YAG rod was coated with a multilayer, dichroic coating for a high reflectance at 1030 nm and high transmission at 941 nm at the pump input end of the rod, thus allowing one end of the rod to perform as a high reflector for the laser cavity. A conjugate coating was placed on the opposite or output end of the rod. The laser rod is typically a composite of doped and undoped YAG. The undoped YAG pieces or endcaps are diffusion bonded to both ends of the doped rod. The endcaps help reduce the thermal loading and stresses on input and output faces of the rod and therefore help prevent damage.

We have operated the Yb:YAG laser in both CW and Q-switched operation. The doping concentration was 0.5% and the rod diameter was 2 mm with an overall length of ~60 mm. The rod was housed in a cooling jacket designed to flow a coolant along the barrel of the rod. The rod temperature was kept close to zero degrees by using a mixture of water and propanol. With our present pump delivery design that includes the microlens and lens duct, we can deliver approximately 50% of the pump light into the end of the rod. Through total internal reflections down the barrel of the rod, the pump light becomes well homogenized with approximately 90% of the pump light being absorbed on the first pass. In cw operation we produced up to 131 W of cw power with an intrinsic optical-to-optical efficiency of 25% as shown in figure 2. An 85% reflective output coupler with a 1 meter radius of curvature was used. The cavity length was approximately 15 cm. Measurements of the beam quality and a least squares fit to the data gave an M^2 value of 6.7 at 100 W of cw output. In addition to the CW measurements, we also

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Q-switched the laser using an acouto-optic Q-switch. The insertion loss from the Q-switch was only 2%. We were able to produce up to 10 mJ in a 40 ns pulse. The repetition rate of the diodes and Q-switch was 5 Hz.

Future plans include going to higher (kHz) repetition rates and frequency converting the output. Planned improvements to the pump delivery design should yield cw powers above 200 W and correspondingly higher Q-switched energies. The details of the data and modeling of our Yb:YAG laser will be presented.

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1. H. Bruesselbach and D. Sumida, "69-W-average-power Yb:YAG laser," Opt. Lett. 21, 480 (1996).

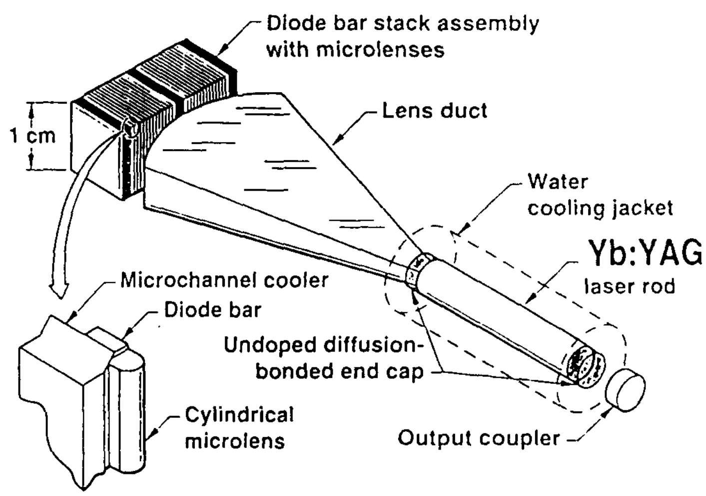

Figure 1: Scheme of the end pumped Yb:YAG laser

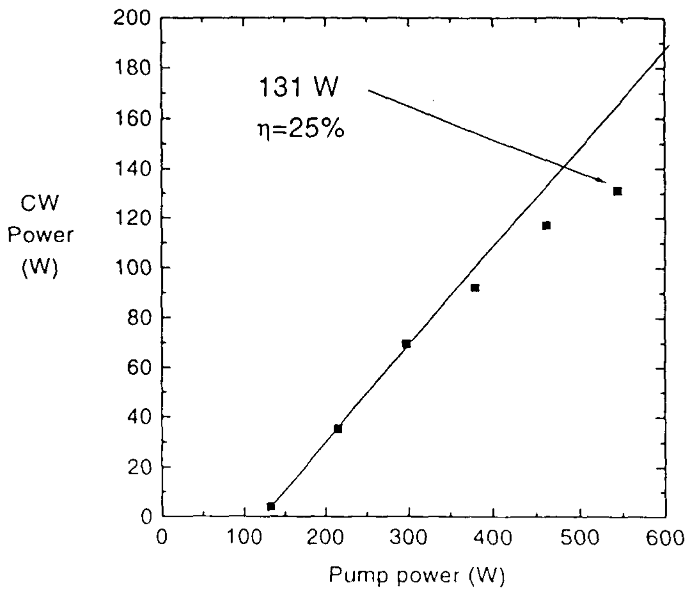

Figure 2: Laser cw output power